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Transfer processes in the chalk critical zone – Multidisciplinary study of the undergound quarry of Saint Martin le Noeud

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The Chalk aquifer is a crucial, vital resource for water supply in France, Belgium and England. However, since several decades, this resource is threatened by high anthropogenic pressures: inducing a degradation of the groundwater's quality.

The aim of our multidisciplinary study is to understand the transfer processes of the water and associated elements - solutes and contaminants (nitrate, pesticides) - throughout the critical zone (CZ) of chalk from the topsoil to the water table.

This study is focused on the underground quarry of Saint Martin le Noeud which is located in the Upper Cretaceous chalk layer of the Paris Basin. A layer of clay-with-flints covers the chalk of the quarry with a variable thickness. At a depth from 16 to 30m, the quarry is about 1200 m long and 150 m wide, giving a direct access to different groundwater compartments: (1) the Chalk water table through a series of 16 underground lakes, and (2) the vadose zone thanks to infiltration water percolating at the ceiling of the quarry. The set-up of this site allows to study the behaviors of both compartments.

Surface geophysical measurements: electrical resistivity tomography and electromagnetic induction mapping, have allowed to describe precisely the structure of the critical zone: in particular the geometry of the clay layer which has a variable thickness from 0 to about 5m.

The hydrodynamic and the quality of the groundwaters of both compartments (vadose zone and Chalk water table) have been characterized in time and space: (1) time series of flow percolation, water level, electrical conductivity and temperature, (2) geochemical analyses (major elements, nitrate, pesticides). The hydrodynamic and geochemical properties of the groundwaters vary spatially along the quarry highlighting different transfer processes.

Time series analysis and geochemical data allow to estimate the transfer velocities of the water

and the contaminants and to precise the biogeochemical reactions (degradation, adsorption/desorption, storage …) that occurs in the CZ. These processes vary spatially depending on the properties of the CZ. The precise description of the clay layer compared to the groundwater behaviors allows to better characterize the infiltration processes. (1) a thin layer of clay induces a “diffuse infiltration”, low velocities, and low degradation of the pesticides in the subsurface, (2) a thick layer of clay induces a perched groundwater in the near-surface, degradation processes, concentrated infiltration and higher velocities.